balloonists to ground in western Virginia and North Carolina. The persistency of this northerly wind zone was one of the outstanding developments of the race, meteorologically speaking.

The next day, the 12th, witnessed the landing of the last of the teams, the winner, the American *Detroit*, Hill, pilot, coming to rest 745 miles almost exactly south of Detroit after a valiant flight of about 48 hours. The second place was captured by the German *Barman*, piloted by Kaulen, who also stayed aloft 48 hours and made a mileage of 688. The remaining four balloons to take prize places, the American *Goodyear*, the French *Lafayette*, the Spanish *Hispania*, and the Belgian *Belgica*, all landed in Georgia or South Carolina during the 12th. As will be seen the speed was slow, averaging 5 to 6 m./s. Toward the end the balloonists were becoming involved in a secondary center of low pressure forming in southern Georgia, and the persistency of the north winds from start to finish may be accounted for in some degree by this low-pressure development.

Hill's experience in the *Detroit* was doubtless shared by the other balloonists in finding that the day winds were churned up by convection so that the best drift southward prevailed at high altitudes above the zone of convective influence; as the north wind may be assumed to have its power maintained by its content of comparatively cool air, the currents just above the ground being cooled by radiative influence should possess the fastest drift. The winner used this "skin" of wind.

Convective activity with its adiabatic vertical temperature gradient means a busy time aboard a balloon, which can never be in equilibrium long while within such a condition and is usually bent on taking either a rapid descent or ascent; if left unchecked, this will result in accelerated vertical motion, which will mean a greater expenditure of ballast or gas. During the 11th and 12th the balloonists found daytime conditions of this sort, developed by sunshine.

Electrical storm activity was more threatening than real, and after the first night the zone of thunderstorms appears to have been located ahead of the balloons and at its worst to have been marked by storms developed more by unstable temperatures than by displaced moisture, and consequently less severe. The weather except at the start was mostly satisfactorily fair and little blind flying was done.

The outcome of the race testifies to the limited nature of the possible courses of action. All the balloons, but one which was disabled over Lake Erie, landed a short distance south of the Appalachian ridges in the Carolinas and Georgia. The similarity of courses and velocities of travel are conclusive evidence that all were playing the same aerial game. Fortunately, neither the sea nor severe weather forced any of them down, while the results speak eloquently of careful ballast economy and persistent search for the best wind streams over a period of time which tried both patience and endurance.

AN EXAMPLE OF WIDESPREAD BUMPINESS IN THE AI

By C. G. ANDRUS

[Weather Bureau office, New York]

Airplane flights over the New York–Cleveland airway October 12, 1927, encountered extraordinary roughness on the air. Roughness, or, as sometimes called, bumpiness, in varying degrees of severity is commonly met but evokes little comment from seasoned aviators unless its intensity becomes a decided handicap in flight. Usually when it is severe it is local, frequently associated with line squalls, tornadoes, violent thunderstorms, or gales upturned by mountain ridges. Inasmuch as the roughness of October 12 extended over about 350 miles of a strip of territory and for more than six hours, it is believed to deserve a brief note.

Pilot Collins arrived at Hadley Airport in the forenoon, after a rough journey from Cleveland, in which he found the rain to be rapidly on the increase both in severity and extent over that which had been reported before he left; the air was moist and warm at moderate altitudes, and within areas of condensation the turbulence was plainly indicated by roughness. At noon he reversed his plane's course, taking off for Cleveland with weather reports which granted a meager amount of ceiling and visibility, a generous supply of rain, and a boisterous SE. and SSE. wind along the course. He landed at the Bellefonte, Pa., landing field at 1:50 p. m., reporting impossble weather for immediate continuation of the flight owing to low ceiling, rain, and severe rough air. He states that the roughness was the worst of his experience, and that it occurred not only just above the ridges but in an even worse manner within the clouds which were outpouring rain one to four thousand feet above the 2,500 feet of the Allegheny Mountains. Tossed about by vertical currents which carried the plane through sudden variations in altitude of more than 1,500 feet, the pilot found it difficult and exhausting to maintain either course or control, so that blind flying became more perilous than usual, for once within the opaque confines of the cloud masses great "bumps" and "pockets" would have separated pilot and plane had he not been belted down.

At the same time another pilot guiding the east-bound mail plane was struggling with the same hazards. During moments when the plane was first on one end and then on the other the altimeter would record tremenduous fluctuations in altitude; running into a heavy rain-squall cloud whose base would be 3,000 feet above sea level, he would be tossed up to 6,000, and while pointing the plane nose down with an air speed of 140 miles per hour would hover there, finally emerging from the cloud into another mass of air in a down current almost as violent. Dodging around such volcanoes of rain, cloud, and air over a sea of mountains and valleys such as in central Pennsylvania is a hazardous practice, and this pilot, H. G. Smith, sought relief in a stop at the Snowshoe, Pa., landing field. Although belted to their seats, both pilots were so thrown about and against their cockpits that they were sore and bruised. The difficulty of keeping their craft pointed in any one direction for a moment at a time has a semblance to the experience of mariners aboard craft which are wallowing in the seas near the eyes of hurricanes; maintaining safe altitude is, however, an added requirement.

An analysis of the conditions from which this roughness arose shows that an unusual combination of two factors provocative of vertical components within air masses was evidently in action. The generation of roughness results from either mechanical or thermodynamical forces; the former are actuated by topographic unevenness which deflects either up or down air passing rapidly over it; the latter operates to give vertical motion or component or velocity to air masses which are potentially unstable. Such unstable air may be found in a dry condition in adiabatic convection resulting from overheating at the base or supercooling at the upper levels, or in a condensation condition within clouds which are the scene for the making of rain or snow and therefore characterized by potential temperatures which may be highly unstable; and another variety is reported by airmen to exist within a thin waferlike stratum of air which appears to act as a friction zone between wind drifts sometimes high aloft containing air of radically different velocities and temperatures, usually and perhaps always with the warmer on top.

From which source did the roughness of October 12 come? The reports point clearly to excessive condensation, and the pilots affirm the presence of the worst roughness within the clouds; the conclusion urged upon us is that the condensation-convection process was violent here. The weather map of 8 a. m. shows a $\frac{6}{10}$-inch barometric gradient across the 400-mile airways. The isobars run NNE.-SSW. and across them [1] races a 20 to 40 mile per hour SE. wind bearing heavy burden of sea-source air. Up to 7,500 feet the wind veered but slightly and increased in velocity. Temperatures were unseasonably high and moisture kept equal pace. A secondary formation in the lower end of a trough of low pressure extending to northwest Florida may have been one agency which held the east component in the circulation; at any rate such widespread SE. wind is uncommon.

The mountain effect on swift-moving air may well be the other source, for with increased horizontal movement comes increased vertical components when such winds climb up and roll down the hills. Too, the ridges in this particular region generally are directed NE.-SW., or nearly transverse to the motion of the air, with the result that it was turned the more abruptly upward.

On November 17, 1927, at about 6 p. m., a mail-plane pilot met with severe bumpiness while over the vicinity of Reading, Pa. A small but severe wind squall, possibly a tornado, occurred northeast of Reading about that time. The bumpiness was less extensive than that of October 12 (as were the contributing causes), but equally violent and probably of similar origin.

[1] The author refers, of course, to surface winds; the gradient winds, say, above 1,500 feet, undoubtedly had a southerly component and thus a direction more nearly parallel with the direction of the isobars.—Ed.

THE GROWTH OF THE NORTHEASTWARD-MOVING CYCLONE IN EASTERN NORTH AMERICA

By W. J. Humphreys

It is a well-known fact that many cyclonic storms greatly increase in size and intensity as they move with a northward component across the United States east of the Mississippi River and over eastern Canada, or along the Atlantic coast. This development of the cyclone with increase of latitude is less marked in most other parts of the world, and in many places practically, if not quite, nonexistent.

Naturally, one might suspect that this marked development is somehow caused by the increase, with increased latitude, of the "deflective force" due to earth rotation. But this force increases by less than 25 per cent as the storm passes from latitude 35° to 45°, for instance, a quantity which, when we take into account, as we must, the cyclostrophic effect, would require only small changes of isobars or wind velocity, and not the great changes that so often occur in eastern North America and on the western Atlantic. Besides, this latitude effect is common to all parts of the earth, while the great growth of the cyclone with increase of latitude is not. The rapid increase in extent and intensity of the northeastward-moving cyclone in the region mentioned must, therefore, depend chiefly on some other cause than the incidental increase of earth deflection.

That cause is suggested by the structure of the extratropical cyclone and the topography of North America. That is, this storm, essentially a swirling passage by each other of a broad and relatively cold polar wind to the west and north, and an equally broad, warm equatorial wind to the south and east, necessarily varies with the contrast in temperature between the two currents and the availability of the air supplies.

As the storm moves to higher latitudes the polar winds have come shorter distances and warmed less, while the temperature of the equatorial winds is largely maintained by condensation. Hence with increase of latitude the temperature contrast of the winds tends to become greater, and therefore the winds stronger if the supply of each current is ample. Now, in the eastern United States and Canada and over the western Atlantic cyclonic storms often move rapidly northeastward, thus increasing the temperature contrasts; and in this region also there is free access, without mountain barrier, to cold air (especially in winter and spring) all the way to the Arctic Ocean. Furthermore, substantially the whole of this vast reservoir is on land and ice, hence its air is very cold. Similarly, the access here to the warm air from the Gulf of Mexico and Atlantic Ocean also is very easy and the air quite humid.

In short, over the region in question cyclones often move northeastward rapidly and increase in temperature contrast, while both the warm and the cold branches of the circulation are but little obstructed and from "inexhaustible" supplies. Such storms, therefore, increase with increase of latitude.

In most other parts of the world the opportunities for increasing temperature contrast between the two portions, polar and equatorial, of the cyclone are not so great, nor the air currents so free from obstruction and from such vast reservoirs. Hence the poleward-moving cyclone grows faster and to a greater extent in eastern North America and over the western Atlantic than in almost any other portion of the world.